

CLAIMS

Therefore, having thus described the invention, at least the following is claimed:

- 1 1. An input/output (I/O) interconnect system, comprising:
2 a first substrate having at least one compliant pillar transversely extending
3 from the first substrate, wherein the compliant pillar comprises a first material, and
4 wherein the compliant pillar includes a non-flat tip at the end opposite the first
5 substrate.
- 1 2. The I/O interconnect system of claim 1, wherein the first material comprises a low
2 modulus material selected from polyimides, epoxides, polynorbornenes, polyarylene
3 ethers, and parylenes.
- 1 3. The I/O interconnect system of claim 1, wherein the compliant pillar has a height
2 of about 15 to 300 micrometers.
- 1 4. The I/O interconnect system of claim 1, wherein the compliant pillar has a length
2 of about 2 to 55 micrometers and a width of about 2 to 55 micrometers.
- 1 5. The I/O interconnect system of claim 1, wherein the first substrate has from about 10
2 compliant pillars to about 500,000 compliant pillars per centimeter squared of the first
3 substrate.

- 1 6. The I/O interconnect system of claim 1, further comprising:
2 a second substrate having at least one compliant socket adapted to receive a
3 compliant pillar, wherein the compliant socket comprises a second material, wherein
4 the compliant socket includes a non-flat top surface at the end opposite the second
5 substrate.
- 1 7. The I/O interconnect system of claim 6, wherein the second material comprises a
2 low modulus material selected from polyimides, epoxides, polynorbornenes,
3 polyarylene ethers, and parylenes.
- 1 8. The I/O interconnect system of claim 6, wherein the compliant socket has a height
2 of about 5 to 30 micrometers.
- 1 9. The I/O interconnect system of claim 6, wherein the compliant socket includes a
2 material that secures the compliant pillar to the compliant socket.
- 1 10. The I/O interconnect system of claim 1, wherein the compliant pillar is used as a
2 transverse waveguide that is substantially perpendicular to the first substrate.
- 1 11. The I/O interconnect system of claim 10, further comprising an element selected
2 from a diffractive grating coupler disposed on the compliant pillar and a mirror
3 disposed on the compliant pillar.

- 1 12. The I/O interconnect system of claim 11, wherein the coupling element is selected
2 from a volume grating coupling element and a surface relief grating coupling element.
- 1 13. The I/O interconnect system of claim 6, further comprising an element selected from a
2 diffractive grating coupler disposed within the second substrate and a mirror disposed
3 within the second substrate.
- 1 14. The I/O interconnect system of claim 7, wherein the second substrate has from about
2 10 compliant sockets to about 100,000 compliant sockets per centimeter squared of
3 the second substrate.
- 1 15. The I/O interconnect system of claim 1, further comprising a lead disposed upon a
2 portion of the compliant pillar.
- 1 16. The I/O interconnect system of claim 15, wherein the lead is a radio frequency lead.
- 1 17. The I/O interconnect system of claim 15, wherein the lead is an electrical lead.
- 1 18. The I/O interconnect system of claim 16, wherein the first substrate has from about 10
2 compliant pillars to about 500,000 compliant pillars per centimeter squared of the first
3 substrate.

- 1 19. The I/O interconnect system of claim 17, wherein the first substrate has from about 10
2 compliant pillars to about 100,000 compliant pillars per centimeter squared of the first
3 substrate.

- 1 20. A dual-mode optical/electrical input/output (I/O) interconnect system, comprising:
2 a first substrate having at least one optical/electrical I/O interconnect that
3 includes a pillar transversely extending from the first substrate, wherein the pillar
4 comprises a first material, the first material is optically conductive, and the pillar
5 includes a lead disposed over a portion of the pillar extending from the base of the
6 pillar on the first substrate to the end opposite the first substrate.
- 1 21. The I/O interconnect system of claim 20, wherein the pillar is a compliant pillar.
- 1 22. The I/O interconnect system of claim 20, further comprising:
2 a second substrate having at least one socket adapted to receive the pillar and
3 the lead, wherein the socket comprises a second material, wherein the second
4 substrate includes a lead contact that communicatively connects the first substrate and
5 the second substrate through the lead, wherein the second substrate includes an
6 optical contact that communicatively connects the first substrate and the second
7 substrate through the pillar.
- 1 23. The I/O interconnect system of claim 22, wherein the second material comprises a
2 low modulus material selected from polyimides, epoxides, polynorbornenes,
3 polyarylene ethers, and parylenes.
- 1 24. The I/O interconnect system of claim 22, wherein the socket is a compliant socket.

- 1 25. The I/O interconnect system of claim 22, wherein the pillar includes a non-flat tip at
2 an end opposite the first substrate.
- 1 26. The I/O interconnect system of claim 22, wherein the first material comprises a
2 low modulus material selected from polyimides, epoxides, polynorbornenes,
3 polyarylene ethers, and parylenes.
- 1 27. The I/O interconnect system of claim 22, wherein the first substrate has from about 10
2 to about 100,000 optical/electrical I/O interconnects per centimeter squared of the
3 first substrate.
- 1 28. The I/O interconnect system of claim 22, further comprising an element disposed on
2 an end of the pillar opposite the first substrate, the element selected from a diffractive
3 grating coupler and a mirror.
- 1 29. The I/O interconnect system of claim 28, wherein the diffractive grating coupler is
2 selected from a volume grating coupling element and a surface relief grating coupling
3 element.

- 1 30. A method for forming a device comprising:
- 2 providing a first substrate having at least one optical/electrical I/O
- 3 interconnect that includes a pillar transversely extending from the first substrate,
- 4 wherein the pillar comprises of a first material, the first material is optically
- 5 conductive, and the pillar includes a lead disposed over a portion of the pillar
- 6 extending from the base of the pillar on the first substrate to the end opposite the first
- 7 substrate;
- 8 providing a second substrate having at least one socket adapted to receive the
- 9 optical/electrical I/O interconnect, wherein the socket comprises a second material,
- 10 wherein the second substrate includes a lead contact that communicatively connects
- 11 the first substrate and the second substrate through the lead, wherein the second
- 12 substrate includes an optical contact that communicatively connects the first substrate
- 13 and the second substrate through the pillar; and
- 14 causing the socket to receive a portion of the optical/electrical I/O
- 15 interconnect.

- 1 31. A method of aligning substrates, comprising:
- 2 providing a first substrate having at least one optical/electrical I/O
- 3 interconnect that includes a pillar transversely extending from the first substrate,
- 4 wherein the pillar comprises of a first material, the first material is optically
- 5 conductive, and the pillar includes a lead disposed over a portion of the pillar
- 6 extending from the base of the pillar on the first substrate to the end opposite the first
- 7 substrate;
- 8 providing a second substrate having at least one socket adapted to receive the
- 9 optical/electrical I/O interconnect, wherein the socket comprises a second material,
- 10 wherein the second substrate includes a lead contact that communicatively connects
- 11 the first substrate and the second substrate through the lead, wherein the second
- 12 substrate includes an optical contact that communicatively connects the first substrate
- 13 and the second substrate through the pillar;
- 14 maintaining optical alignment between the first substrate and the second
- 15 substrate using the optical/electrical I/O interconnect and the socket; and
- 16 maintaining electrical interconnection between the first substrate and the
- 17 second substrate using the optical/electrical I/O interconnect and the socket.

1 32. A method of directing optical energy and electrical energy, comprising:
2 providing a first substrate having at least one optical/electrical I/O
3 interconnect that includes a pillar transversely extending from the first substrate,
4 wherein the pillar comprises of a first material, the first material is optically
5 conductive, and the pillar includes a lead disposed over a portion of the pillar
6 extending from the base of the pillar on the first substrate to the end opposite the first
7 substrate;
8 providing a second substrate having a socket adapted to receive the
9 optical/electrical I/O interconnect, wherein the socket comprises a second material,
10 wherein the second substrate includes a lead contact that communicatively connects
11 the first substrate and the second substrate through the lead, wherein the second
12 substrate includes at least one optical contact that communicatively connects the first
13 substrate and the second substrate through the pillar;
14 communicating optical energy between the pillar of the first substrate and the
15 optical contact of the second substrate; and
16 communicating electrical energy between the lead of the first substrate and the
17 lead contact of the second substrate.

1 33. A method for fabricating a device having at least one compliant pillar comprising:
2 providing a substrate;
3 disposing a material onto at least one portion of the substrate; and
4 removing portions of the material to form at least one pillar on the substrate
5 having smooth sidewalls that are configured at a substantially right angle with respect
6 to the substrate.

1 34. The method of claim 33, further comprising:
2 forming at least one lead on a portion of the compliant pillar, wherein the lead
3 extends from the base of the pillar on the substrate to the end opposite the substrate.

1 35. The method of claim 33, wherein the pillar includes a non-flat tip at the end opposite
2 the substrate.

1 36. The method of claim 33, wherein the material comprises a low modulus material
2 selected from polyimides, epoxides, polynorbornenes, polyarylene ethers, and
3 parylenes.

1 37. The method of claim 33, further comprising:
2 forming an coupling element on the pillar.

- 1 38. The method of claim 33, further comprising:
2 forming about 10 to about 100,000 pillars per centimeter squared on the
3 substrate.

- 1 39. An input/output (I/O) interconnect, comprising:
- 2 a substrate having at least one compliant pillar transversely extending from the
- 3 first substrate, wherein the compliant pillar comprises a first material being optically
- 4 conductive, wherein the compliant pillar includes a lens disposed at the end opposite
- 5 the first substrate, wherein the lens being adapted to focus optical energy.

1 40. A device, comprising:
2 a substrate including an overcoat polymer layer, a sacrificial polymer layer
3 disposed at a first location between the substrate and the overcoat polymer layer,
4 wherein the sacrificial polymer layer can be removed from the first location to form a
5 compliant polymer bridge.

1 41. The device of claim 40, further comprising a pillar disposed on the compliant bridge.

- 1 42. An input/output (I/O) interconnect system, comprising:
- 2 a first substrate having an L-shaped compliant pillar transversely extending
- 3 from the first substrate, wherein the compliant pillar comprises a first material.